A DOE SUCCESS: Automated Nuclear Weapon Component Handling

The Project: The Nuclear Weapons Complex stores and handles thousands of radioactive nuclear materials, "pits," during annual operation. At the Mason & Hanger Pantex Plant in Amarillo, Texas, many stockpile inspection, evaluation, and maintenance programs require the handling and measurement of pits from a wide variety of weapons systems. Currently, all pit handling operations are performed manually, resulting in a significant accumulation of radiation dose to the workers at the plant. Typical operational steps include unpacking pits from their shipping or storage containers, disassembling shipping fixtures that hold the pits, moving the bare pits to a variety of measurement and inspection stations, re-assembling the shipping fixtures, and repacking the containers for storage or shipment.

The Weigh and Leak Check System (WALS) was developed to provide an automated robotic system capable of performing remote weigh and leak check operations on pits at Pantex. These measurements are performed periodically to ensure stockpile integrity. The WALS also performs the tasks of unpacking and repacking the pits in their shipping fixtures and containers. The use of the robotic system emphasizes an ALARA approach to reducing human exposure to radiation; WALS effectively eliminates all direct human contact handling operations on pits in the weigh and leak check facility.

WALS uses a six-axis robot on a linear track to access the stations and move pits within the automation workcell. Custom tooling and automation stations were developed to perform the unpacking, handling, and repacking operations. The weigh and leak check stations were designed for automated servicing by the robot. The project was a joint effort: the robotic automation system was developed by Sandia National Laboratories, and the weigh and leak check stations were developed by Pantex.

There were significant challenges faced by the designers in automating a process that uses older containers, pits, and fixtures that were never designed for automated handling. An added challenge was the requirement to handle a wide variety of materials—different pit types from many weapons systems and different sizes of shipping fixtures and containers—with flexibility in the measurements to be performed. To improve throughput with limited space and resources, the system was required to be able to process several pits at a single time. In addition, an essential requirement on the system was to incorporate design elements that ensured safety in handling these nuclear materials.

The WALS robotic system employs advanced automation technologies to provide safety in performing difficult operations and that simplify operator use of the system. Computer vision is used extensively to determine the position of objects in the workcell, thereby eliminating the need for large numbers of precise fixtures. Force-control is used to allow the robot system to sense forces on the payload, thereby protecting the payload and providing an automated means to precisely and gently place pits in the workcell in spite of mechanical imprecision. The system

uses extensive sensors to ensure the proper state of the workcell, and in many cases, to allow automated methods for calibration and self-testing. Finally, a significant design and analysis effort resulted in mechanical and electrical interlocks and engineered safety features that provide the means, independent from software, for ensuring safety in automated pit handling.

The WALS robotic automation system uses a hybrid approach that allows automation to be used on a large percentage of the stockpile pits, but operation can also be switched to manual handling for those pits not suitable for automation. This approach ensures maximum utilization of the facility's resources.

Many user-friendly features were employed in the operator interface. Barcode entry of product information, graphical user interfaces, computerized operator instructions and checklists, product databases, interactive computer vision, and electronically recorded log events all work together to reduce operator errors, reduce training requirements, and improve quality.

The Impact: The primary benefit of WALS is the elimination of operator exposure to hazardous radiation during unpacking of pits, weighing, leak checking, and repacking pits. An important added ergonomic benefit is the elimination of many of the manual lifting tasks that are required for the container unpacking and repacking operations.

Automating the processes with a robot has additional benefits, as well. Once a procedure has been programmed, tested, and qualified, there can be high confidence that it will be executed the same each time. Use of automation enforces the use of qualified, validated procedures. In addition, the sequence of performed operations automatically generates a log that can be retained and audited, thus improving quality. These benefits from automation can be especially important in a workcell where a wide variety of materials (pit and containers types and sizes) are handled – some not very frequently. Differences in procedures for the different types can be stored in the automation program, resulting in fewer human errors and reduced operator training requirements.

The WALS is ready to become operational at the Pantex Plant. Since its shipment from Sandia to Pantex the system has been completely integrated into the facility and with the Pantex-developed automated measurement systems. Extensive system testing has been performed, resulting in improvements that have increased the operational reliability of this complex system. Operational procedures and documentation have been completed. Contingency procedures for off-normal events have been developed. On-site experts have been trained. Production technicians have been formally trained and drilled for normal and off-normal operations. Several reviews of the system have been conducted at Pantex. When operational, WALS will be the first robot system ever to handle stockpile pits.

Future Advances through a RIM Initiative: The automation technologies developed for WALS can be employed in a wide variety of areas where pits are handled. This will dramatically extend the scope of these technologies, focused on safe handling of nuclear materials, well beyond their original use in the weigh and leak check facility.

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